# *On some remarkable composite crystals of copper pyrites from Cornwall.*

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[Read January 23rd, 1900.]

During a recent visit to Cornwall the attention of Professor Lewis was directed by Mr. James Wickett to some composite crystals of copper pyrites recently found in one of the deep mines in the neighbourhood of Redruth. On the specimens acquired by the Cambridge Museum about thirty crystals show this composite growth, which causes the crystals to resemble ill-developed pentagonal dodecahedra of iron pyrites. Many of them are much tarnished, and some show purple and blue colours due to thin films: and they are deposited together with small brilliant crystals ( {100} and {111} ) of hæmatite on a matrix of chalybite, which at the surface is developed in minute lenticular crystals.

## *Simple crystals.*

The habit of most of the crystals is notably sphenoidal, owing to the predominance of two forms, which are in some cases a very obtuse sphenoid and a very acute one; in other cases the obtuse sphenoid is replaced by the pinakoid or by the pinakoid alternating with the faces of an obtuse sphenoid. The obtuse sphenoid is either $l=\kappa\{114\}$, or $\lambda=\kappa\{229\}$, or $\gamma=\kappa\{115\}$, or $\beta=\kappa\{118\}$. The acute sphenoid is one of the following: $\rho=\kappa\{553\}$, $r=\kappa\{332\}$, $t=\kappa\{221\}$, $f=\kappa\{552\}$, $u=\kappa\{441\}$, $F=\kappa\{551\}$, $T=\kappa\{22\bar{1}\}$.

The faces of the above sphenoids, of the pinakoid $c\{001\}$, and in many cases those of the prism $m\{110\}$ are deeply striated in a direction parallel to the edges in which faces in a vertical zone intersect. This striation has rendered it very difficult to determine the symbols of the forms. Another difficulty was likewise encountered, for measurements between tautozonal faces on opposite sides of the principal axis often differed by 4° or 5°; and it was occasionally observed that on one side the face (441) or (551) is largely developed, whilst on the other side the face $(\bar{1}\bar{1}0)$ is the conspicuous one. The sphenoid $o=\kappa\{11\bar{1}\}$ is generally present, but the faces are always very small; they are, however, fairly free from striæ, and measurements from them to faces in adjacent vertical zones have served to check the determination of the symbol of these latter faces. The sphenoid $T=\kappa\{22\bar{1}\}$ is often present, but the faces are in all cases very dull.

Faces of one or both of the pyramids $e\{101\}$, $z\{201\}$ often occur as small triangles modifying the coigns on the horizontal edges in which the faces of the obtuse sphenoid or pinakoid meet the faces of the acute sphenoid. The faces $z$ are striated each in a direction which seems to be parallel to the edge of intersection with an adjacent face (111); each face $e$ in a direction parallel to the adjacent face $(1\bar{1}1)$. The faces of these forms are usually bright, but the striæ have much interfered with their usefulness in determining the symbols of particular faces or in confirming the twin-law.

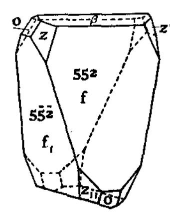


FIG. 1.

Fig. 1 represents a very small crystal on which the forms $\beta=\kappa\{118\}$, $f=\kappa\{552\}$, $o=\kappa\{1\bar{1}1\}$, $z=\{201\}$ were definitely determined. Close inspection of the coigns at which the faces $z$ appear reveals the presence of two or three additional forms, the faces of which are too striated to admit of accurate measurement. Measurements of the angles between faces of one of these forms and those of $z$ accord fairly well with the form being $\kappa\{825\}$; the faces of another form belong to $e\{101\}$. The faces of these two forms, being very subordinate, have been omitted in the drawing. The faces $z$ are striated parallel to the edges of intersection with the adjacent faces of $\kappa\{825\}$.

A second crystal measured shows the forms $\lambda=\kappa\{229\}$, $\gamma=\kappa\{332\}$, $m\{110\}$, $T=\kappa\{22\bar{1}\}$. The coigns at which faces $\lambda$, $r$ and $T$ meet are modified by well developed faces $\sigma$, which are striated in the same way as the faces $z$ in the first crystal. The measurements between homologous faces $\sigma$ do not agree with those of $e\{101\}$; and the form nearly accords with {1, 12, 12}. The same displacement of the faces from the position of those of the pyramid $e$ was also observed on one of the twin-crystals described further on.

In a third crystal the faces of the pinakoid $c\{001\}$ and of the sphenoid $F=\kappa\{551\}$ are largely developed; those of the sphenoid $\lambda=\kappa\{229\}$ are narrow planes modifying the obtuse edges $[c\,F]$. The faces of the sphenoid $o=\kappa\{1\bar{1}1\}$, and of the pyramid $e\{011\}$ are very small. The symbols of the faces $\lambda$ are deduced from measurements of the angles $o\wedge\lambda$; for the faces $\lambda$ and of the pinakoid are much striated parallel to their common edge. The face $c$ in this and other crystals, on which the inclination to other faces was measured, seems generally to be a good deal displaced. Thus, $c\wedge\lambda'(\bar{2}\bar{2}9)$ was found to be 16°4′, and $c\wedge\lambda(229)$ to be 18°48′. That it is the face $c$ which is displaced was shown by measurement of the angles $o\lambda$ and $o\lambda'$; for $o\lambda=56°7'$ and $o\lambda'=56°20'$.

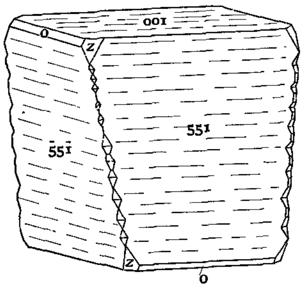


Fig. 2.

Fig. 2 represents a crystal having a somewhat cubic habit. The forms present are, according to measurements made with a contact-goniometer, taken to be $\kappa\{551\}$, $\{001\}$, $\{201\}$, $\{100\}$. The faces $o$ and $z$ are very small; and pairs of the latter alternate with faces of the tetragonal prism $\{100\}$ in such a way as to give the appearance of a deeply furrowed face which truncates the slanting edges of the acute sphenoid. The relative dimensions of these alternating faces to those of the sphenoid are much exaggerated in the drawing. In some crystals of this habit the sphenoid seems to be $\kappa\{441\}$ or $\kappa\{552\}$, and occasionally the faces of the prism $\{110\}$ are also present. In a few cases the crystals have an irregular development, owing to the fact that the predominant faces consist of two or three faces of the acute sphenoid associated with one or two faces of the prism $\{110\}$. Thus we get the crystal sometimes bounded by the pinakoid $\{001\}$, a pair of opposite faces of the sphenoid, such as $(5\bar{5}\bar{2})$, $(\bar{5}5\bar{2})$, and a pair of opposite prism-faces (110), $(\bar{1}\bar{1}0)$. A crystal of this type is shown in Fig. 3, which gives approximately the relative sizes of the faces. The crystal is an acute wedge which is much elongated along the edge of intersection of the two predominant faces of the sphenoid $\kappa\{552\}$.

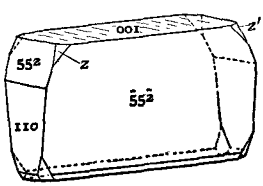


Fig. 3.

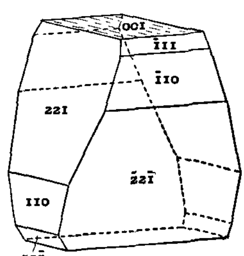


Fig. 4.

Fig. 4 represents in equable and normal development the general habit resulting from the combination of forms $\{001\}$, $\kappa\{221\}$, $\{110\}$, $\kappa\{11\bar{1}\}$. But the forms are commonly unequably developed; and, as illustrated by Fig. 8, the faces of $\kappa\{221\}$ are sometimes interrupted, and a prism-face (110) is interposed between two portions of the same face (221).

*Twin-crystals.*

The twin-axis is the normal to a face of the sphenoid $o = \kappa\{1\bar{1}1\}$.

The peculiar resemblance to iron pyrites of the most remarkable of the twins arises from the great development of the obtuse sphenoid. In the twins of this character the individuals are mostly in juxtaposition; but the combination-surface is rarely a definite plane, and there is a certain amount of interlocking, and in many cases portions of one individual protrude beyond the other. The depth of striation also causes a considerable irregularity in the edges common to the two individuals. If a crystal like one of those represented in Figs. 1 and 4 is bisected by a central plane perpendicular to the twin-axis, the edges in which the plane of section meets the faces will not be all congruent after one portion has been turned through 180° about the twin-axis. Supposing the normal $(1\bar{1}1)$ to be the twin-axis, the two prism-faces (110) and $(\bar{1}\bar{1}0)$ which are parallel to it change places, and these faces will be co-planar in the twin. Again, the faces in the zone $[001, 1\bar{1}1]$, which includes the face $o(1\bar{1}1)$, are tautozonal in the twin; and any pair of such faces which meet intersect in a line parallel to the edges of the zone. Thus, in the somewhat idealised doublet shown in Fig. 5, the face $T(\bar{2}21)$ intersects $\underline{i}_{,}(1\bar{1}\bar{4})$ in a re-entrant edge parallel to the edge $[\underline{l}_{,}\underline{l}_{,,}]$. In this doublet the two faces 221 and $(\bar{2}\bar{2}\bar{1})$, which belong to the complementary sphenoids $\kappa\{221\}$ and $\kappa\{22\bar{1}\}$, are represented as equably developed on opposite sides of the combination-plane, which has been taken to be $(1\bar{1}1)$ perpendicular to the twin-axis; and this is very nearly the case in the quartet of which three individuals are shown in Fig. 6. In some cases the individuals are juxtaposed approximately along a plane which belongs to a different form in each individual. Thus in several of the twins the combination-plane is $t(221)$ of one individual and $\underline{c}(001)$ of the other. In twins of this character the individual having $\underline{c}$ for combination-plane is usually smaller than the other, and is often reduced to such small dimensions that it looks much like a limpet deposited on a relatively large (221) face of the large individual.

In other cases the one individual completely penetrates the other, the imbedded individual being always small compared with the other. An instance of this case of the twin is shown in Fig. 8, where a striated face $\underline{c}_{,}$ appears as an irregular patch in the face $t(221)$, with which $\underline{c}_{,}$ is practically co-planar; the theoretical angle between the two being 1°4′. On the face adjacent to $t$ the imbedded twin-individual appears as a wedge inserted in the crystal. Occasionally the patch forms, as it were, an island in the face $t$ : such patches are very noticeable, for the striæ on $\underline{c}_{,}$ are at right angles to those on the face $t$ and to those on the face $c$ which is inclined to the patch at an angle of 71°20′.

The twin-law was established by measurements of the angles $l\wedge \underline{l}_{,}$, $l'\wedge \underline{l}_{,}$, $l\wedge \underline{l}_{,,}$, $l'\wedge \underline{l}_{,,}$, $\underline{o}\wedge \underline{o}_{,}$, $\underline{o}\wedge \underline{o}_{,,}$ ; and of a zone $[\underline{l}_{,,}\underline{l}_{,}\ \underline{\mathrm{l}}'\underline{\mathrm{l}}]$, common to two individuals, which are united to a middle one about the homologous twin-axes $1\bar{1}1$ and $\bar{1}11$ respectively. The measurements in this zone were:—$\underline{t}_{,,}\underline{l}_{,,} = 50°21'$, $\underline{l}_{,,}\underline{l}_{,} = 38°3'$, $\underline{\mathrm{l}}'_{,}\underline{\mathrm{l}} = 103°25'$, $\underline{\mathrm{l}}'\underline{\mathrm{l}} = 38°5'$, $\underline{\mathrm{l}}\,\underline{\mathrm{t}} = 50°13'$, $\underline{\mathrm{lm}} = 72°12'$. The face $l$ being (114), the twin-law gives $\underline{l}_{,}\wedge\underline{\mathrm{l}}' = 104°16'$, and $t$ being (221), $\underline{t}_{,,}\wedge\underline{\mathrm{t}} = 283°12'$, whilst the sum of the angles from $\underline{t}_{,,}$ to $\underline{\mathrm{t}}$ is 280°7′, and again $\underline{t}_{,,}\wedge\underline{\mathrm{m}} = 302°56'$, measured 302°6′. The measured angle $l\wedge\underline{l}_{,} = 114\wedge(1\bar{1}\bar{4})$ was found to be 55°0′, and $l'\wedge\underline{\mathrm{l}}' = \bar{1}\bar{1}4\wedge(1\bar{1}\bar{4})$ to be 54°43′, whilst the computed value is 54°34′. The measured angle $l\wedge\underline{l}_{,,} = 114\wedge(\bar{1}1\bar{4})$ is 90°8′, $l'\wedge\underline{l}_{,,} = \bar{1}\bar{1}4\wedge(\bar{1}1\bar{4})$ is 90°1′; the computed value being 90°30′. Further, $o\wedge\underline{o}_{,} = 1\bar{1}1\wedge(\bar{1}\bar{1}\bar{1}) =$ 109°19′, $o\wedge\underline{o}_{,,} = 1\bar{1}1\wedge(11\bar{1}) = 110°25'$; the computed value being 109°54′.

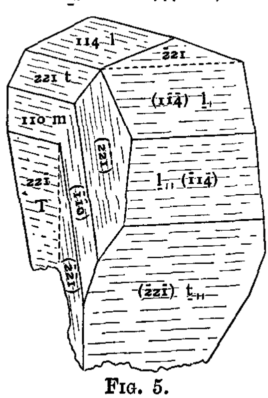

FIG. 5.

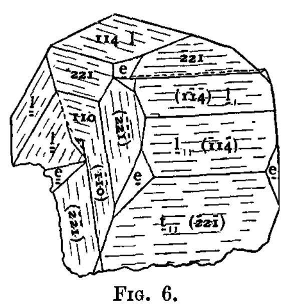

FIG. 6.

Fig. 6 represents a twin in which three unequal individuals are united to a central one about homologous axes. The first individual (that to the right) is twinned to the upright one about the normal $(1\bar{1}1)$ ; the second (that to the front) about the normal $(11\bar{1})$ ; and the third, which is very small and has its faces $l$ tautozonal with those of the individual to the right, is twinned to the upright one about $(\bar{1}11)$.

Two individuals are frequently united to a larger one in the manner just described for the first and third individuals ; *i.e.* the latter are twinned to the central individuals about the normals to faces $(1\bar{1}1)$ and $(\bar{1}11)$, which are tautozonal with (001) of the larger crystal. The measurements in such a zone have been already given.

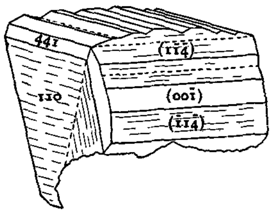


FIG. 7.

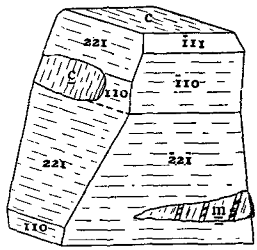


FIG. 8.

Fig. 7 shows an instance of a doublet in which but few forms are present. The pinakoids are largely developed, but very rough. They are mainly composed of ridges formed by alternating faces of an obtuse sphenoid, which may be $\kappa\{118\}$, or $\kappa\{114\}$, &c. The acute sphenoid has been taken to be $\kappa\{441\}$, and the composite face shown is apparently (110); but the crystal has only been measured by a contact goniometer, for the faces are rough, dull and much tarnished. This twin represents an intermediate stage between those of the type shown in Figs. 5 and 6 and those, like Fig. 8, in which the twin is only shown by a patch imbedded in a face *t* (221) of an apparently simple crystal.

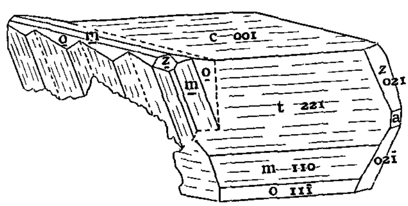


FIG. 9.

Fig. 9 shows a twin of a different habit. This twin differs so much from all the others that we at first thought we had to deal with two different laws; but measurements easily established that $(1\bar{1}1)$ is the twin-face. The drawing shows with fair approximation the relative dimensions of the faces.

A second wedge of inserted matter is shown on the face $(\bar{2}2\bar{1})$ of Fig. 8 protruding into the crystal. At the back of the crystal a horizontally striated patch is observed; and the patch consists of a face *c*, which seems co-planar with the face $t'(\bar{2}\bar{2}1)$. If the faces $t''$ and *c* were approximately co-planar, the striæ on the latter should be in a vertical plane; and it seemed as if the inserted matter had further undergone a quarter-revolution about its principal axis. Careful examination convinced the authors that the appearance of the two faces being co-planar was deceptive, and that the inserted matter has been turned through 180° about the normal $(11\bar{1})$. This is shown by the fact that the coarse markings on $m$ are practically parallel to the face $t(221)$; and the face $c$ to which they are parallel is therefore really parallel to $t$, and not to $t'$.

In drawing asymmetric twins such as those which we have described there is some difficulty in determining the directions of the edges in which non-homologous faces meet. Such edges are often most easily found by taking approximate values for the parameters which give rational indices to the faces of the rotated crystal, when the latter is referred to the axes of the fixed individual. Mr. R. W. H. T. Hudson,[1] B.A., of St. John's College, has been good enough to determine a formula which gives the position of a face-normal after a rotation of 180° about any twin-axis, and also a more generalised one which applies when the angle of rotation is $\theta$. In applying his general formulæ to the twins of copper pyrites, the crystal is taken to have rectangular axes and equal parameters; *i.e.* to be, as far as computations are concerned, cubic. The twin-axis being now taken to be $(1\bar{1}1)$, and $(h_1k_1l_1)$ being the symbol of a face or normal which is $(hkl)$ before a semi-revolution about $(1\bar{1}1)$, then the new indices are given by the equations:—

$$\left.\begin{aligned} 3h_1 &= -3h+2(h-k+l), \\ 3k_1 &= -3k-2(h-k+l), \\ 3l_1 &= -3l+2(h-k+l), \end{aligned}\right\} \ldots\ldots(1)$$

In the case of copper pyrites the new symbol of any face $(hkl)$ can be also easily found from the above-mentioned approximation to the parameter $c$, and the following two relations:—(1) That the face in its new position is in a zone with $o$ and its original position; (2) That its inclination to $o$ remains unchanged. Hence $(hkl)$ being the original face, and $(h_1k_1l_1)$ its symbol after a semi-revolution about $(1\bar{1}1)$, we have the equations:—

$$\begin{vmatrix} h_1 & k_1 & l_1 \\ 1 & \bar{1} & 1 \\ h & k & l \end{vmatrix} = 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2);$$

[1] Mr. Hudson's formulæ are given in the *Mineralogical Magazine*, XII, p. 345, 1900.

$$\text{Cos } oP = \frac{h-k+l}{\sqrt{3}\sqrt{h^2+k^2+l^2}} = \frac{h_1-k_1+l_1}{\sqrt{3}\sqrt{h_1^2+k_1^2+l_1^2}} \ldots\ldots \ldots\ldots\ldots (3).$$

By substituting in (3) the value obtained from (2) of one of the unknown indices—$k_1$ (say)—in terms of the two others, a quadratic equation in the two indices $h_1$, $l_1$ is found. The roots of this equation are easily obtained; for it must break up into two linear factors, one of which must be $h_1 l — h l_1$. Thus for $l_{,}(1\bar{1}\bar{4})$ equation (2) gives—

$$h_1 + k_1 = 0 \quad \ldots \quad \ldots \quad ;$$

and equation (3) becomes—

$$(4h_1 + l_1)\ (8h_1 + 7l_1) = 0.$$

Hence the face in its new position has the symbol $(\bar{7}78)$.

The following table gives the position after a semi-revolution about $o(1\bar{1}1)$ of a face having the symbol given in the second column:—

| | Originally. | | After rotation. | | Originally. | | After rotation. |
|---|---|---|---|---|---|---|---|
| $l_{,,}$ | $\bar{1}1\bar{4}$ | ... | $\bar{1}\bar{1}0$ | $o_{,,}$ | $\bar{1}\bar{1}\bar{1}$ | ... | $151$ |
| $c_{,}$ | $00\bar{1}$ | ... | $\bar{2}21$ | $A_{,}$ | $010$ | ... | $212$ |
| $l_{,}$ | $1\bar{1}\bar{4}$ | ... | $\bar{7}78$ | $e$ | $101$ | ... | $1\bar{4}1$ |
| $t_{,}$ | $2\bar{2}\bar{1}$ | ... | $001$ | $m$ | $110$ | ... | $\bar{1}\bar{1}0$ |
| $m$ | $1\bar{1}0$ | ... | $1\bar{1}4$ | $t$ | $221$ | ... | $\bar{4}\bar{8}\bar{1}$ |
| | | | | $l$ | $114$ | .. | $5\,\overline{11}\,\bar{4}$ |

The principal angles measured on the crystals are given in the following table: the striation and tarnish of the faces render it impossible to get really trustworthy measurements.

| Angles measured. | | No. of Observations. | Extremes. | Mean. | Calculated. |
|---|---|---|---|---|---|
| *oc* | 111 ∧ 001 | 11 | 53°17′— 54°45′ | 54° 8′ | 54°20′ |
| *ll′* | 114 „ $\bar{1}\bar{1}4$ | 6 | 37 55 — 39 56 | 38 31 | 38 25 |
| λλ′ | 229 „ $\bar{2}\bar{2}9$ | 8 | 32 17 — 36 10 | 34 24 | 34 24 |
| γγ′ | 115 „ $\bar{1}\bar{1}5$ | 2 | 29 23 — 29 53 | 29 38 | 31 8 |
| ββ′ | 118 „ $\bar{1}\bar{1}8$ | 1 | .. | 19 34 | 19 46 |
| *rr′* | 332 „ $\bar{3}\bar{3}2$ | 2 | 126 59 —128 4 | 127 32 | 128 52 |
| *cr* | 001 „ 332 | 6 | 62 53 — 65 0 | 63 49 | 64 26 |
| ρρ′ | 553 „ $\bar{5}\bar{5}3$ | 1 | .. | 131 57 | 133 24 |
| *c*ρ | 001 „ 553 | 4 | 65 35 — 67 48 | 66 48 | 66 4 |
| *tt′* | 221 „ $\bar{2}\bar{2}1$ | 1 | .. | 138 54 | 140 32 |
| *ct* | 001 „ 221 | 8 | 69 15 — 71 42 | 70 20 | 70 16 |

| Angles Measured. | No. of Observations. | Extremes. | Mean. | Calculated. |
|---|---|---|---|---|
| $ff'$ 552 ∧ $5\bar{5}2$ | 1 | .. | 147°22′ | 147°58′ |
| $cf$ 001 ,, 552 | 2 | 72°56′ — 75°45′ | 74 20 | 73 59 |
| $cF$ 001 ,, 551 | 1 | .. | 81 6 | 81 50 |
| $c_{,}u$ $00\bar{1}$ ,, $4\bar{4}\bar{1}$ | 1 | .. | 101 37 | 100 10 |
| $cm$ 001 ,, 110 | 1 | .. | 90 32 | 90 0 |
| $om$ $1\bar{1}1$ ,, $1\bar{1}0$ | 7 | 35 13 — 37 44 | 36 39 | 35 40 |
| $mT$ 110 ,, $22\bar{1}$ | 1 | .. | 22 25 | 19 44 |
| $l\rho$ 114 ,, 553 | 3 | 47 16 — 48 41 | 48 2 | 47 30 |
| $tt_{,}$ 221 ,, $2\bar{2}\bar{1}$ | 1 | .. | 97 1 | 96 33 |
| $ee'$ 101 ,, 011 | 1 | .. | 59 27 | 59 30 |
| $ee''$ 101 ,, $\bar{1}01$ | 1 | .. | 89 50 | 89 9 |
| $ae$ 100 ,, 101 | 1 | .. | 45 45 | 45 25 |
| $zz'$ 201 ,, $0\bar{2}1$ | 6 | 76 30 — 79 43 | 78 11 | 78 11 |
| $oz$ $1\bar{1}1$ ,, 201 | 5 | 35 44 — 39 50 | 38 19 | 39 6 |
| $mz$ $1\bar{1}0$ ,, 201 | 1 | .. | 50 38 | 50 54 |
| $az$ 100 ,, 201 | 2 | 27 26 — 27 33 | 27 29 | 26 54 |
| $zz''$ 201 ,, $\bar{2}01$ | 1 | .. | 125 11 | 126 11 |
| $el$ 101 ,, 114 | 4 | 31 17 — 33 48 | 32 3 | 33 17 |
| $el'$ 101 ,, $\bar{1}\bar{1}4$ | 3 | 59 10 — 60 2 | 59 44 | 59 22 |
| $\xi\xi'$ 825 ,, 285 | 1 | .. | 51 59 | 52 0 |
| $o\lambda$ $1\bar{1}1$ ,, 229 | 2 | 56 7 — 56 20 | 56 13 | 56 9 |
| $oe$ $1\bar{1}1$ ,, 101 | 1 | .. | 35 45 | 35 4 |
| $oe'$ $1\bar{1}1$ ,, 011 | 1 | .. | 89 14 | 89 18 |
| $or$ $1\bar{1}1$ ,, 332 | 1 | .. | 76 16 | 75 26 |
| $er$ 101 ,, 332 | 1 | .. | 41 46 | 40 58 |
| $\sigma\sigma'$ 1,12,12 ∧ 12,1,12 | 2 | 53 37 — 55 24 | 54 30 | 54 2 |
| $\sigma\sigma''$ 1,12,12 ,, $\bar{1},\bar{12},12$ | 2 | 89 25 — 89 50 | 89 38 | 89 20 |
| $\sigma\sigma'''$ 1,12,12 ,, $\bar{12},\bar{1},12$ | 4 | 63 0 — 65 43 | 63 52 | 64 54 |
| $m\sigma$ 110 ∧ 1,12,12 | 1 | .. | 57 29 | 57 33 |
| $o\underline{o}_{,,}$ $1\bar{1}1$ ,, $(11\bar{1})$ | 1 | .. | 109 19 | 109 52 |
| $o\underline{o}_{,}$ $1\bar{1}1$ ,, $(\bar{1}\bar{1}\bar{1})$ | 1 | .. | 110 25 | |
| $l\underline{l}_{,}$ 114 ,, $(1\bar{1}\bar{4})$ | 1 | .. | 55 0 | 54 34 |
| $l'\underline{l}_{,}$ $\bar{1}\bar{1}4$ ,, $(1\bar{1}\bar{4})$ | 1 | .. | 54 43 | |
| $l\underline{l}_{,,}$ 114 ,, $(\bar{1}1\bar{4})$ | 1 | .. | 90 8 | 90 30 |
| $l'\underline{l}_{,,}$ $\bar{1}\bar{1}4$ ,, $(\bar{1}1\bar{4})$ | 1 | .. | 90 1 | |